Moving Away From Wheat/ Fallow in the Great Plains

Dynamic agricultural systems—as opposed to fixed ones—allow Northern Plains farmers to quickly adjust to major changes in international markets, weather, or government policies. They are also reversing the trend toward specialization, finding instead that broadening their options is helping them compete.

Gone are the days of planting just wheat every other year, alternately leaving soil fallow to perhaps store precious water. Now farmers are planting a crop every year, carefully choosing from among a dozen or more possibilities.

"Dynamic agricultural systems" is what Jon Hanson, research leader at the ARS Northern Great Plains Research Laboratory in Mandan, North Dakota, calls the new farming approach that's based on research he and colleagues have done. It allows farmers to choose from various management options such as diversified crop sequences and livestock to obtain the greatest economic return while minimizing expense and risk each year. ARS scientists are doing similar research at several locations in the Great Plains, including Akron and Fort Collins, Colorado.

Hanson says a major component of the system is "a long-term strategy of planting crops every year while balancing economic and environmental factors." It involves not only choosing from among many different crops, but also using no-till methods, if possible, to plant the crops without plowing first.

Current research at the lab demonstrates that dynamic cropping can enhance soil quality and productivity while improving the environment. Diverse crop species encourage soil microfauna, which can help reduce soilborne plant diseases. "Using beneficial microbes, rather than pesticides, keeps production costs down while also protecting the environment," Hanson says.

Hanson and colleagues have extensively researched 100 combinations of 10 crops grown in rotation sequences: barley, canola, crambe, dry bean, dry pea, flax, safflower, soybean, sunflower, and spring wheat. They have since expanded the research to include another such matrix. This one comprises buckwheat, canola, chickpea, corn, dry pea, lentil, proso millet, sorghum, and spring wheat.

The lab issues farmers a free "Crop Sequence Calculator" on CD-ROM to help them choose from 100 crop combinations.

"The dynamic agricultural system is a way family farmers can create a sustainable environment while generating income," Hanson says.

STEPHEN AUSMUS (D098-9)

Soil scientist Merle Vigil and technician Donna Fritzler make a quick assessment of erosion damage in a tilled field near Akron, Colorado. In the background is a field that shows no erosion after using the no-till intensive dryland cropping system developed at the Central Great Plains Research Station at Akron.

The Alternative Crop Rotation Experiment

Like farmers in the Northern Great Plains, those in the Central Great Plains have traditionally grown wheat one season and left the ground fallow the next. This is not the ideal situation for economics or the environment. Leaving the field fallow hurts the soil by decreasing its organic matter while increasing the likelihood of erosion. The rotation also wastes a lot of water through evaporation when the soil is bare.

In 1990, a team of researchers at the ARS Central Great Plains Resources Management Research Unit in Akron, Colorado, began the long-term alternative crop rotation study to find useful, profitable, and sustainable rotations. The team started with 23 rotations. Over the years they ended rotations that weren't successful and tried other combinations.

Each phase of each rotation is grown each year. That way, the scientists get results quicker. Also, because weather is so variable in the region, the scientists get results in both dry and wet years for all crops in all rotations.

The scientists, led by research leader Merle F. Vigil, discovered several rotations that work well in the Central Great Plains, which includes parts of Colorado, Wyoming, South Dakota, Nebraska, and Kansas. The team looked at crops such as corn, peas, proso millet, safflower, sunflower, triticale, and winter wheat, with some crops grown for grain and some for forage. The best rotations they found usually lasted 3 or 4 years, such

W. BRIEN HENRY (D102-1)

An aerial view highlights the various crops growing in the alternative cropping system plots at the USDA-ARS Central Great Plains Research Station.

STEPHEN AUSMUS (D096-33)

Biologist Brien Henry (foreground) and technician Paul Campbell test for herbicide-resistant weeds using a rapid, spectrophotometric leaf disk assay.

as growing wheat the first year, corn the second, and then leaving the field fallow for the third. Two other rotations that proved successful were wheat/corn/millet/fallow and wheat/corn/millet.

"In dryland cropping, water controls everything," according to Akron agronomist David C. Nielsen who is responsible for looking at every aspect of water in the system. During the growing season, he'll take measurements every 7 to 14 days. By looking at crop growth and development, he can see how efficiently water is used in the rotation system.

Nielsen has helped find the best order for crops to be grown in the Central Great Plains based on water efficiency. Each crop takes up water differently. Sunflower plants, which have deep roots, use nearly all the water stored in the soil each season, while shallow-rooted millet uses much less.

The key is to use water efficiently. Several of the successful systems have no water-wasting summer fallow periods between crops.

The amount and type of crop residue and how that residue is managed also affect precipitation storage efficiency and, therefore, the yield of the next crop. Yield for corn was about 15 percent lower in the rotations of wheat/corn/millet and wheat/corn/sunflower/millet than in wheat/corn/millet/fallow and wheat/corn/fallow. This is because wheat residue production is less following millet than following fallow, resulting in lower precipitation storage efficiency and lower available soil water for corn.

Nielsen and Vigil found that 10 to 20 bushels more corn grew in stripper head-harvested wheat stubble than in conventionally harvested stubble. Crop residue amounts were the same; the difference was in how the residue was managed.

Sunflower did best in 4-year rotations because of reductions in insects and diseases. Corn and sunflower had the most variability in the studies; wheat and millet had the least. Just like financial advisors suggest diversifying your portfolio to protect against variability, the Akron team thinks farmers should diversify to minimize impact of weather variability.

Vigil is trying to find other reasons for the different yields in the rotations. He is looking mainly at the top 2 inches of soil. He's noticed that the pH of the soil changes and that metal availability goes up in certain systems. Vigil is trying to find out why. He's also comparing nutrient cycles.

With soil chemist Maysoon Mikha and soil microbiologist Francisco Calderón, Vigil will evaluate both beneficial and antagonistic microbial/plant associations for these systems and changes in soil quality that can affect yields. They have already found significant increases in soil organic matter in rotations without fallow.

ARS soil physicist Joseph G. Benjamin started working on the project in 1997. He is studying how soil physical properties

Agronomist David Nielsen (right) uses a neutron probe while technician Martin Walker uses time domain reflectometry to measure soil water use by growing winter wheat in the alternative crop rotation study.

STEPHEN AUSMUS (D100-17)

change with crop rotation over time. Some of the soil factors he measures are bulk density (weight of soil per volume), water holding capacity, and soil strength. These factors interact, affecting root growth, soil water uptake, and, ultimately, crop yield.

So far, he hasn't noticed much change in soil properties in most rotations. "Soil changes occur over long periods, so we need to continue doing long-term experiments," Benjamin explains. He thinks that changes in soil physical properties may not be measurable for 15 or 20 years.

Weed scientist Brien Henry is new to the project, having started 2 years ago. He is studying weed control in the various rotations, especially how different harvest techniques affect how much residue is left on the soil. Residues help decrease weeds naturally, which means less herbicide is needed.

Successful weed-control experiments need to be conducted on plots larger than those available in the alternative crop rotation experiment (30 feet by 100 feet). Henry has started a large wheat/sorghum/millet rotation to mimic the alternative crop rotation.

Local farmers have noticed how successful the crop rotation research has been and have started to change their farming practices. Corn, millet, and sunflower acreage has gone up dramatically near the research center. "I hope our research will show other farmers in the region that alternative rotations will likely be good for their bottom line as well as for the environment," says Vigil.

Ken Remington, who runs a 1,000-acre farm about 25 miles from Vigil's laboratory, has followed the lab's research closely. He's changed from a mostly wheat/fallow rotation to one that uses corn and millet and has experimented with other crops that were successful in Akron. Remington said that the wheat/fallow rotation was not good economically for him, while his corn rotations are "easily" three times more profitable than the wheat ones.

Another local farmer, David Wagers, changed the rotations on his 6,000-acre farm from a wheat/fallow rotation partly because of the research coming from Akron. He changes rotations based on what's profitable at the time but usually includes wheat and corn and either millet, sunflower, or fallow.

STEPHEN AUSMUS (D099-22)

In an alternative cropping system plot, technician Brandon Peterson measures carbon dioxide loss due to tillage.

DAVID NIELSEN (D101-1)

Sunflowers and proso millet plots in the alternative crop rotation plots. In this experiment 23 alternative no-till dryland-crop rotations are compared to the old wheat-fallow system.

Vigil notes that many farmers may be reluctant to switch from conventional wheat-fallow to the more intense no-till rotations because they'll have to buy additional equipment and learn about the new crops' insect, weed, and disease cycles and markets.

Since 2001, the Akron scientists have worked with fellow ARS scientists of the Great Plains Systems Research Unit in Fort Collins, Colorado. The scientists at this lab, led by soil scientist Laj Ahuja, are experts in computer models. They can put the results from the Akron scientists into models they created to predict long-term effects of rotations. The computer-generated findings can be used by farmers throughout the Great Plains region, taking into account differences in things like climate, soil, and farming practices. The modelers also hope to discover how each different factor, such as rain or planting date, affects yields each year.

Vigil sees the experiments lasting for many years to come, since new rotations will be added and others dropped and because changes in soil quality can take decades.—By **David Elstein** and **Don Comis,** ARS.

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Soil scientist Joseph Benjamin and technician Stacey Poland measure water-holding characteristics of soil using pressure cells.